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Dated: 23 November, 2004

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Applicants: PASHBY, Gary J., et al. Docket No. 2220PCT

Serial No : PCT/US03/24255

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For : SEALED INTEGRAL MEMS SWITCH

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This communication responds to a First Written Opinion of the United States International Preliminary Examining Authority dated the 23 September 2004, for the patent application identified above.

AMENDMENTS

Pursuant to PCT Rule 66.8, replacement sheets for pages 17 and 26-31 together with a new page 31.1 accompany this communication. These sheets, which contain amendments to the international patent application as originally filed, replace identically numbered sheets in that application. The replacement sheets

contain the following amendments to the international application as originally filed.

Page 17, line 21,	the phrase "front surface 142" replaces reference number "174" thereby conforming the terminology in line 21 of the patent application to similar terminology occurring throughout the immediately preceding paragraph on page 17.
Pages 26-28,	independent claim 1 and dependent claim 2 have been amended to incorporate therein subject matter which appeared in dependent claim 10 of the patent application as originally filed. In addition to adding to claims 1 and 2 subject matter which previously appeared in dependent claim 10, the formatting of claims 1 and 2 has been revised to more clearly particularize the invention.
Page 29,	dependent claim 4 has been amended to incorporate therein subject matter which appeared in dependent claim 10 of the patent application as originally filed, and the formatting of dependent claim 4 has been revised to conform with that now appearing in amended claims 1 and 2.
Page 30,	line 1 of dependent claims 6-9 have been amended by inserting before the word "claims" in the texts thereof as originally filed the phrase "any one of." Conforming to the amendment of

claims 1, 2 and 4, dependent claim 10 has been canceled.

Page 31, line 1 of claim 11 has amended to depend from any one of claims 1 through 9 rather than from now canceled dependent claim 10.

REMARKS

In view of the preceding amendments and following remarks, the applicants respectfully request reconsideration and revision of:

1. the non-establishment of opinion under PCT Rule 6.4(a) with respect claims 6-9, 11 and 12; and
2. the reasoned statement under Article 33(2) with regard to a lack of novelty and Article 35(2) with regard to lack of inventive step for claims 1-5, 13 and 14.

The Claimed Invention

The invention, as presently recited in amended independent claim 1, is an integral, i.e. one piece, micro-electro mechanical systems ("MEMS") switch assembled by bonding together three (3) layers of material. The middle layer of the structure, identified in independent claim 1 as the monolithic layer, includes a seesaw which is rotatable about an axis established by torsion bars which support the seesaw from a surrounding frame. Rotation of the seesaw about the axis causes a shorting bar located at one end of the seesaw to contact a pair of switch contacts present on a substrate which is bonded to a surface of the monolithic layer. The structure encompassed by independent claim 1 as amended herein also includes a ground plate which is disposed adjacent to and is electrically insulated from electrical conductors which connect the switch contacts respectively to first input and output conductors.

The structures encompassed by amended dependent claims 2 and 4, which respectively depend from independent claim 1, have also been amended to include ground plates.

As contrasted with independent claim 1, independent claim 13 and 14 do not encompass a MEMS switch formed by bonding together three (3) layers of material. Rather, independent claims 13 and 14 encompass MEMS contact structures respectively formed between two (2) layers of a MEMS structure. Each of the two (2) layers respectively carries an electrical conductor. The MEMS electrical contact structure respectively encompassed by independent claims 13 and 14 includes a cantilever formed in one of the layers and which carries an electrical contact island at a free end of the cantilever. The contact island is located at an end of the cantilever which is furthest from a portion of the cantilever which carries the other layer's electrical conductor. **A portion of the electrical conductor located at the end of the electrical contact island is urged into intimate contact by force supplied by the cantilever with the electrical conductor on the other layer**. Thus, independent claims 13 and 14 respectively encompasses using mechanical force, supplied by the cantilever, for forming a fixed, non-switching electrical connection between electrical conductors respectively located on each of two (2) layers of a MEMS structure.

The Cited References

The Kasano et al. Patent

United States Patent No. 5,278,368 entitled "Electrostatic Relay" which issued January 11, 1994, on an application filed by Fumihiro Kasano, Hiromi Nishimura, Jun Sakai, Koichi Aizawa, Keiji Kakite and Takayoshi Awai ("the Kasano, et al. patent"), discloses, with respect to a "moveable plate" third embodiment illustrated in FIGs. 6A-8, that:

> [a]n electrostatic relay 1a of the present invention essentially consists of two mechanical elements, that is, a fixed plate 10a and a movable plate 20a as shown in FIG. 6a and 6b. Each of the plates was made of a single crystal of silicon. The two mechanical elements were bonded by gold alloy layers 14a and 24a. The movable plate 20a is arranged on the fixed plate 10a and constituted by a frame 21a, a movable electrode plate 22a, a coupling segment 23a and a torsion bar 25a which are integrally formed from the silicon wafer into an unitary structure by an anisotropic etching of silicon. The torsion bar 25a with the movable electrode 22a are continuously connected with

the frame 21a by the coupling segment 23a to form the unitary structure. The movable electrode plate 22a is pivotally supported at its intermediate portion between its ends in a seesaw fashion so as to move about the pivot axis intermediates the ends of the movable electrode plate 22a. Each of movable contacts 26a and 26a' is arranged on the movable electrode plate with an electrical insulation layer 27a and at the ends of the movable electrode 22a, respectively as shown FIG. 2. A fixed electrode 11a and two pairs of fixed contacts 12a and 12a' are formed on the fixed plate with an electrical insulation layer 15a. The pair of the fixed contacts 12a is also arranged so as to have close and open positions between the pair 12a and the movable contact 26a. Similarly, the other pair 12a' is arranged so as to have close and open positions between the other pair 12a' and the other movable contacts 26a'. By the way, two electrets 16a and 17a are positioned on the fixed electrode 11a in such a manner as to be interposed between the fixed electrode and the movable electrode plate 22a on opposite sides of the pivot axis. The fixed electrets 16a and 17a have the opposite charges, respectively, in order to provide a torque for moving the relay. The control voltage source 30a is connected, by a wire bonding, with a terminal pad 28a of the movable plate 20a as shown in FIG. 6a and also with a terminal pad 13a of the fixed electrode 10a in order to generate the potential difference between the movable electrode and the fixed electrode. (Col. 7, lines 6-46)

With respect to a "moveable plate" fourth embodiment depicted in FIGs. 12A-13, the Kasano, et al. patent discloses that:

[a] forth embodiment of the present invention is identical in structure to the third embodiment except that one of the two electrets has larger surface area compared with the other electret as shown in FIG. 12B. Therefore no duplicate explanation to common parts are deemed necessary. Like parts are designated by like numerals with a suffix letter of "b" in place of "a". (Col. 8, lines 36-40)

With respect to a "moveable plate" fifth embodiment depicted in FIGs. 15A-18, the Kasano, et al. patent discloses that:

[a]n electrostatic relay 1d of the present invention essentially consists of three mechanical elements, that is, a lower fixed plate 10d, a movable plate 20d and an upper fixed plate 30d, as shown in FIGS. 15A, 15B and 15C. Each of the plates was made of a single crystal of silicon. The three mechanical elements were bonded by gold alloy layers 14d and 24d. An electrical insulation layer 27d' is interposed between the gold layer 24d and the movable electrode 22d in order to insulate the upper electrode 31d from

the frame 21a by the coupling segment 23a to form the unitary structure. The movable electrode plate 22a is pivotally supported at its intermediate portion between its ends in a seesaw fashion so as to move about the pivot axis intermediates the ends of the movable electrode plate 22a. Each of movable contacts 26a and 26a' is arranged on the movable electrode plate with an electrical insulation layer 27a and at the ends of the movable electrode 22a, respectively as shown FIG. 2. A fixed electrode 11a and two pairs of fixed contacts 12a and 12a' are formed on the fixed plate with an electrical insulation layer 15a. The pair of the fixed contacts 12a is also arranged so as to have close and open positions between the pair 12a and the movable contact 26a. Similarly, the other pair 12a' is arranged so as to have close and open positions between the other pair 12a' and the other movable contacts 26a'. By the way, two electrets 16a and 17a are positioned on the fixed electrode 11a in such a manner as to be interposed between the fixed electrode and the movable electrode plate 22a on opposite sides of the pivot axis. The fixed electrets 16a and 17a have the opposite charges, respectively, in order to provide a torque for moving the relay. The control voltage source 30a is connected, by a wire bonding, with a terminal pad 28a of the movable plate 20a as shown in FIG. 6a and also with a terminal pad 13a of the fixed electrode 10a in order to generate the potential difference between the movable electrode and the fixed electrode. (Col. 7, lines 6-46)

With respect to a "moveable plate" fourth embodiment depicted in FIGs. 12A-13, the Kasano, et al. patent discloses that:

> [a] forth embodiment of the present invention is identical in structure to the third embodiment except that one of the two electrets has larger surface area compared with the other electret as shown in FIG. 12B. Therefore no duplicate explanation to common parts are deemed necessary. Like parts are designated by like numerals with a suffix letter of "b" in place of "a". (Col. 8, lines 36-40)

With respect to a "moveable plate" fifth embodiment depicted in FIGs. 15A-18, the Kasano, et al. patent discloses that:

> [a]n electrostatic relay 1d of the present invention essentially consists of three mechanical elements, that is, a lower fixed plate 10d, a movable plate 20d and an upper fixed plate 30d, as shown in FIGS. 15A, 15B and 15C. Each of the plates was made of a single crystal of silicon. The three mechanical elements were bonded by gold alloy layers 14d and 24d. An electrical insulation layer 27d' is interposed between the gold layer 24d and the movable electrode 22d in order to insulate the upper electrode 31d from

the movable plate 20d. A fixed electrode 11d and two pairs of fixed contacts 12d and 12d' are formed on the lower fixed plate 10d with an electrical insulation layer 15d. The pair of fixed contacts 12d is also arranged so as to have close and open positions between the pair and the movable contact 26d. Similarly, the other pair of the fixed contacts 12d' is arranged so as to have close and open positions between the other pair and the other movable contact 26d'. On the other hand, a fixed electrode 31d without fixed contacts are formed on the upper fixed plate 30d with an electrical insulation layer 37d. The movable plate 20d is positioned between the upper and the lower fixed plate 30d and 10d, and also constituted by a frame 21d, a movable electrode plate 22d, a coupling segment 23d and a torsion bar 25d which are integrally formed from the silicon wafer into the unitary structure by the anisotropic etching of silicon. The movable electrode plate 22d is pivotally supported at its intermediate portion between its ends in a seesaw fashion so as to move about the pivot axis intermediates the ends of the movable electrode plate 22d. Each of two movable contacts 26d and 26d' is arranged on the movable electrode plate with an electrical insulation layer 27d and at the ends of the movable electrode 22d, respectively as shown in FIG. 16. By the way, two lower electrets 16d and 17d are positioned on the lower fixed electrode 11d in the same manner as the third embodiment. The two lower electrets 16d and 17d have the opposite charges, respectively. On the other hand, the two upper electrets 36d and 37d are also positioned on the upper fixed electrode 31d in such a manner as to be interposed between the upper fixed electrode 31d and the movable electrode 22d on opposite sides of the pivot axis. The two upper electrets 36d and 37d have the opposite charges, and also the opposite charges with respect to the lower electrets, respectively, that is, when the lower electret 17d has the negative charges, the upper electret 37d has the positive charges as shown in FIG. 16. A control voltage source is connected, by a wire bonding, with a terminal pad 28d of the movable plate 20d as shown in FIG. 17 and also with a terminal pad 13d of the fixed electrode 10d in order to generate the potential difference between the movable electrode and the lower fixed electrode. (Col. 9, line 17 - col. 10, line 2)

With respect to a "cantilever" first embodiment depicted in FIGs. 1A-3, the Kasano, et al. patent discloses that:

[a]n electrostatic relay of the present invention essentially consists of three mechanical elements, that is, a lower fixed plate 10, a movable plate 20, an upper fixed plate 30 as shown in FIGS. 1A, 1B and 1C. The three mechanical elements were bonded by gold alloy layers 14, 24 and 34 as shown in FIG. 2. Each

of the plates is made of a single crystal of silicon. The lower fixed plate 10 has a fixed electrode 11 and a pair of fixed contacts 12, which are insulated from the lower plate 10 by an electrical insulation layer 15. An electrical insulation layer 27' is arranged on each surface of a frame 21 of the movable plate 20 in order to insulate the movable electrode 22 from the upper plate 30 and the lower plate 10. On the other hand, the upper fixed plate has a fixed electrode 31 which is insulated from the upper plate 30 by an electrical insulation layer 35. The movable plate is arranged between the upper and lower fixed plates and constituted by the frame 21, a movable electrode plate 22, a coupling segment 23 and a torsion bar 25, which are integrally formed from the silicon wafer into an unitary structure by an anisotropic etching of silicon. The torsion bar 25 with the movable electrode 22 are continuously connected with the frame 21 by the coupling segment 23 to form the unitary structure. **The movable electrode plate 22 is pivotally supported at its one end in a cantilever fashion so as to move about the pivot axis at the one end and also has a movable contact 26 with an electrical insulation layer 27 at the other end and on a surface opposed to the lower fixed contacts 12 as shown in FIG. 2. Therefore, the electrostatic relay 1 of the present invention has one pair of the movable contact 26 and the fixed contacts 12**. However, in an another case of the present invention, it is also preferred that an electrostatic relay has two pairs of a movable contact and a fixed contact when the movable contact is arranged at each surface of a movable electrode plate opposed to lower and upper fixed contacts, respectively. By the way, an upper electret 33 with positive charges is positioned on the upper fixed electrode 31. On the other hand, a lower electret 13 with negative charges is also positioned on the lower fixed electrode 11. **A control voltage source (not shown) is connected with a terminal pad 28 of the movable plate 20 as shown in FIG. 3 and also with a terminal pad 16 of the lower fixed electrode 11 by a wire bonding in order to generate the potential difference between the movable electrode and the lower fixed electrode.** A corner 29 and a part 29' of the movable plate 20 were cut off to readily perform the wire-bonding. The other terminal pad 17 which is also insulated from the lower fixed plate 10 is connected with the terminal pad 28 by bonding the movable plate 20 and the lower fixed plate 10. (Col. 4, line 52 - col. 5, line 35) (Emphasis supplied.)

Continuing to describe operation of the "cantilever" first embodiment depicted in FIGs. 1A-3, the Kasano, et al. patent discloses that:

The spring bias [of the movable electrode 22] also works to the opposite direction of the electrostatic

> force, but, in the FIG. 4, the spring bias was shown to the same direction with the **electrostatic force** as a matter of convenience. As also shown in FIG. 2, when the movable electrode is spaced from and parallel with the upper and lower electrodes 31 and 11, respectively, by same distance, in the absence of the potential differences between them, the movable electrode is held at a center position between the electrodes. On the other hand, the electrostatic relay is also formed such that the **electrostatic forces of the electrets 13 and 33**, respectively, are larger than the spring bias. The movable electrode 22 receives the **electrostatic force** toward the upper electrode when the movable electrode is positioned close to the upper electret 33. Secondly, when a positive voltage is loaded to the movable electrode 22, the movable electrode receives **strong electrostatic forces** toward the lower electrode 11 which has the electret 13 with negative charges. Because an attracting force generated between the movable electrode 22 and the lower electret 13, and also a repelling force is generated between the movable electrode 22 and the upper electret 33. Therefore, both of the attracting and repelling forces cause the movable electrode 22 to move to the lower electret 13, so that the movable contact 26 connects with the fixed contacts 12. (Col. 5, line 61 - col. 6, line 22) (Emphasis supplied.)

Arguments

Claim 1-9, 11 and 12

Because independent claim 1 as amended herein includes a ground plate which is disposed adjacent to and is electrically insulated from electrical conductors which connect the switch contacts respectively to first input and output conductors, Applicants respectfully submit that, for reasons set forth below, pending claims 1-9, 11 and 12 possess both novelty and inventive step over the disclosure of the Kasano, et al. patent.

FIGs 6a-6B, 7, 12A-12B, 13, 15B-15C and 16 of the Kasano, et al. patent respectively depict electrically insulated pairs of fixed contacts (respectively 12a and 12a', 12b and 12b', and 12d and 12d') that are deposited on a lower fixed plate (respectively 10a, 10b and 10d). The lower fixed plate in the Kasano, et al. patent corresponds to the substrate in pending amended independent claim 1.

The Kasano, et al. patent discloses that the lower fixed plate is bonded to a moveable plate (respectively 20a, 20b and

20d). Formed in the moveable plate are a moveable electrode plate (respectively 22a, 22b and 22d) which is supported by torsion bars (25a, 25b and 25d) from a surrounding frame (21a, 21b and 21d). Opposite ends of the moveable electrode plate carry moveable contacts (respectively 26a and 26a', 26b and 26b', and 26d and 26d') that are disposed adjacent to the pairs of fixed contacts which, as described above, are on the lower fixed plate. The moveable plate in the Kasano, et al. patent corresponds to the monolithic layer in amended claim 1.

The Kasano, et al. patent discloses that the moveable electrode plate is rotatable in a seesaw fashion about a pivot axis established by the torsion bars. Rotation of the moveable electrode plate about the pivot axis in one direction causes moveable contacts 26a, 26b or 26d to contact and electrically connect pairs of fixed contacts 12a, 12b or 12d. Rotation of the moveable electrode plate about the pivot axis in an opposite direction causes moveable contacts 26a', 26b' or 26d' to contact and electrically connect pairs of fixed contacts 12a', 12b' or 12d'. Rotation of the moveable electrode plate in the Kasano, et al. patent corresponds to rotation of the seesaw in the pending claims.

Ends of pairs of fixed contacts furthest from the moveable electrode plate's moveable contacts, which FIGs. of the Kasano, et al. patent depict as extending horizontally outward beyond a periphery of the smaller moveable plate, provide a place for making electrical connections to the fixed contacts. Thus, the fixed contacts in the Kasano, et al. patent correspond to a combination of pending claims 1-9, 11 and 12's:

1. first and second input and output conductors;
2. first and second electrical conductor in the amended claims; and
3. first and second pair of switch contacts.

Neither the FIGs. of the Kasano, et al. patent nor that reference's text disclose, nor do they suggest, a ground plate which is disposed adjacent to and is electrically insulated from the electrical conductors as encompassed by pending claims 1-9, 11 and 12. Because the Kasano, et al. patent does not disclose, nor does it suggest, a ground plate which is disposed adjacent

to and is electrically insulated from the electrical conductors, Applicants, therefore, respectfully submit that claims 1-9, 11 and 12:

1. are novel with respect to all the embodiments of the electrostatic relay disclosed in the Kasano, et al. patent; and
2. possesses an inventive step over all the embodiments of the electrostatic relay disclosed in the Kasano, et al. patent.

For the preceding reasons, Applicants respectfully request that the reasoned statement under Rule 66.2(a)(ii) of the Written Opinion be revised to indicate that claims 1-9, 11 and 12, as amended herein, possess both novelty and inventive step with respect to the disclosure of the Kasano, et al. patent.

Independent Claims 13 and 14

As described above, independent claims 13 and 14 respectively encompass using mechanical force, supplied by a cantilever, for forming a fixed, non-switching electrical connection between electrical conductors respectively located on each of two (2) layers of a MEMS structure. The text of the pending application beginning on page 15 at line 34 describes the MEMS structure encompassed by claims 13 and 14 as follows.

> The second RIE etch also opens the initial cavity 144 to the cavities 112 and 116 in the base wafer 104 leaving **cantilevers 166 beneath and supporting each of the grounding islands 152**. Supporting each grounding island 152 at a free end of a cantilever 166 accommodates the thickness of the Au at the ends of the ground plates 162a and 162b atop each grounding island 152 which projects above the front surface 142. **Compliant force supplied by the cantilever 166 ensures formation of a good electrical contact between the ground plates 162a and 162b and subsequent metalization layers described below**.

Continuing to describe the MEMS structure encompassed by claims 13 and 14, the text of the pending application beginning on page 17 at line 20 states as follows.

> During anodic bonding of the metalization surface 172 to the front surface 142, **the cantilevers 166 supporting the grounding islands 152 deflect due to interference between the metal of the ground plates 162a and 162b that is atop each grounding island 152 and of the**

grounding pads 186 formed on the metalization surface 172 of the glass substrate 174. Mechanical stiffness of the single crystal silicon material forming the cantilevers 166 provides forces which ensure a sound electrical connection between the grounding pads 186 and the portions of the ground plates 162a and 162b juxtaposed therewith at the grounding islands 152.

Portions of FIG. 11, included in Exhibit A attached hereto, that graphically illustrate the grounding islands 152 depict in dashed lines bending of the cantilevers 166 which provides the compliant force that ensures formation of a sound electrical contact between:

1. the grounding pads 186 on the substrate, and
2. portions of the ground plates 162a and 162b atop each grounding island 152.

As excerpted above, the Kasano, et al. patent, with respect to its first and second embodiments depicted in FIGs. 1A-3, discloses that:

> **a movable electrode plate 22** is pivotally supported at its one end in a cantilever fashion so as to **move about the pivot axis** at the one end and also has a movable contact 26 with an electrical insulation layer 27 at the other end and on a surface opposed to the lower fixed contacts 12 as shown in FIG. 2.

Both the title of, together with the text excerpted above from, the Kasano, et al. patent, also clearly establish that movement of the moveable electrode plate 22 is effected by electrostatic forces resulting both from forces supplied by:

1. electrets 13 and 33, and
2. a control voltage connected between:
   a. the movable plate 20; and
   b. the lower fixed electrode 11.

Accordingly, the Kasano, et al. patent discloses with respect to its first embodiment depicted in FIGs. 1A-3:

1. a pivotally supported movable electrode plate 22 which provides no force for establishing an electrical connection; and
2. urging rotation of the movable electrode plate 22 for forming an electrical connection between a pair of fixed contacts by means of engagement with the moveable contact carried by the moveable electrode plate

22 through application of **electrostatic force** to the moveable electrode plate 22.

Conversely, **the texts of pending independent claims 13 and 14 respectively expressly require that the cantilever itself provide force for forming a fixed, non-switching electrical connection between electrical conductors** respectively located on each of two (2) layers of a MEMS structure. Therefore, Applicants respectfully submit that independent claims 13 and 14:

1. are novel with respect to the electrostatically energized, pivotally supported movable electrode plate 22 depicted in FIGs. 1A-3 of the Kasano, et al. patent; and
2. possesses an inventive step over the electrostatically energized, pivotally supported movable electrode plate 22 depicted in FIGs. 1A-3 of the Kasano, et al. patent.

For the preceding reasons, Applicants respectfully request that the reasoned statement under Rule 66.2(a)(ii) of the Written Opinion in IPEA be revised to indicate that independent claims 13 and 14 possess both novelty and inventive step with respect to the disclosure of the Kasano, et al. patent.

Conclusion

Applicants respectfully submit that claims 6-9, 11 and 12 as amended herein now conform to PCT Rule 6.4(a), and therefore request establishment of an opinion for the patentability of those claims.

For the reasons set forth above, because claims 1-9, 11 and 12 include ground plates which the Kasano, et al. patent does not disclose or suggest, Applicants respectfully submit that claims 1-9, 11 and 12 possess, with respect to all embodiments of the electrostatic relay disclosed in Kasano, et al. patent, both novelty under PCT Article 33(2) and inventive step under PCT Article 33(3).

Moreover, since dependent claim 12 encompasses the same subject matter as independent claims 13 and 14, for the reasons set forth above with respect to claims 13 and 14 Applicants respectfully submit that, for a second independent reason, claim

to and is electrically insulated from the electrical conductors, Applicants, therefore, respectfully submit that claims 1-9, 11 and 12:

1. are novel with respect to all the embodiments of the electrostatic relay disclosed in the Kasano, et al. patent; and
2. possesses an inventive step over all the embodiments of the electrostatic relay disclosed in the Kasano, et al. patent.

For the preceding reasons, Applicants respectfully request that the reasoned statement under Rule 66.2(a)(ii) of the Written Opinion be revised to indicate that claims 1-9, 11 and 12, as amended herein, possess both novelty and inventive step with respect to the disclosure of the Kasano, et al. patent.

Independent Claims 13 and 14

As described above, independent claims 13 and 14 respectively encompass using mechanical force, supplied by a cantilever, for forming a fixed, non-switching electrical connection between electrical conductors respectively located on each of two (2) layers of a MEMS structure. The text of the pending application beginning on page 15 at line 34 describes the MEMS structure encompassed by claims 13 and 14 as follows.

> The second RIE etch also opens the initial cavity 144 to the cavities 112 and 116 in the base wafer 104 leaving **cantilevers 166 beneath and supporting each of the grounding islands 152**. Supporting each grounding island 152 at a free end of a cantilever 166 accommodates the thickness of the Au at the ends of the ground plates 162a and 162b atop each grounding island 152 which projects above the front surface 142. **Compliant force supplied by the cantilever 166 ensures formation of a good electrical contact between the ground plates 162a and 162b and subsequent metalization layers described below**.

Continuing to describe the MEMS structure encompassed by claims 13 and 14, the text of the pending application beginning on page 17 at line 20 states as follows.

> During anodic bonding of the metalization surface 172 to the front surface 142, **the cantilevers 166 supporting the grounding islands 152 deflect due to interference between the metal of the ground plates 162a and 162b that is atop each grounding island 152 and of the**

grounding pads 186 formed on the metalization surface 172 of the glass substrate 174. Mechanical stiffness of the single crystal silicon material forming the cantilevers 166 provides forces which ensure a sound electrical connection between the grounding pads 186 and the portions of the ground plates 162a and 162b juxtaposed therewith at the grounding islands 152.

Portions of FIG. 11, included in Exhibit A attached hereto, that graphically illustrate the grounding islands 152 depict in dashed lines bending of the cantilevers 166 which provides the compliant force that ensures formation of a sound electrical contact between:

1. the grounding pads 186 on the substrate, and
2. portions of the ground plates 162a and 162b atop each grounding island 152.

As excerpted above, the Kasano, et al. patent, with respect to its first and second embodiments depicted in FIGs. 1A-3, discloses that:

> **a movable electrode plate 22** is pivotally supported at its one end in a cantilever fashion so as to **move about the pivot axis** at the one end and also has a movable contact 26 with an electrical insulation layer 27 at the other end and on a surface opposed to the lower fixed contacts 12 as shown in FIG. 2.

Both the title of, together with the text excerpted above from, the Kasano, et al. patent, also clearly establish that movement of the moveable electrode plate 22 is effected by electrostatic forces resulting both from forces supplied by:

1. electrets 13 and 33, and
2. a control voltage connected between:
   a. the movable plate 20; and
   b. the lower fixed electrode 11.

Accordingly, the Kasano, et al. patent discloses with respect to its first embodiment depicted in FIGs. 1A-3:

1. a pivotally supported movable electrode plate 22 which provides no force for establishing an electrical connection; and
2. urging rotation of the movable electrode plate 22 for forming an electrical connection between a pair of fixed contacts by means of engagement with the moveable contact carried by the moveable electrode plate

22 through application of **electrostatic force** to the moveable electrode plate 22.

Conversely, **the texts of pending independent claims 13 and 14 respectively expressly require that the cantilever itself provide force for forming a fixed, non-switching electrical connection between electrical conductors** respectively located on each of two (2) layers of a MEMS structure. Therefore, Applicants respectfully submit that independent claims 13 and 14:

1. are novel with respect to the electrostatically energized, pivotally supported movable electrode plate 22 depicted in FIGs. 1A-3 of the Kasano, et al. patent; and
2. possesses an inventive step over the electrostatically energized, pivotally supported movable electrode plate 22 depicted in FIGs. 1A-3 of the Kasano, et al. patent.

For the preceding reasons, Applicants respectfully request that the reasoned statement under Rule 66.2(a)(ii) of the Written Opinion in IPEA be revised to indicate that independent claims 13 and 14 possess both novelty and inventive step with respect to the disclosure of the Kasano, et al. patent.

Conclusion

Applicants respectfully submit that claims 6-9, 11 and 12 as amended herein now conform to PCT Rule 6.4(a), and therefore request establishment of an opinion for the patentability of those claims.

For the reasons set forth above, because claims 1-9, 11 and 12 include ground plates which the Kasano, et al. patent does not disclose or suggest, Applicants respectfully submit that claims 1-9, 11 and 12 possess, with respect to all embodiments of the electrostatic relay disclosed in Kasano, et al. patent, both novelty under PCT Article 33(2) and inventive step under PCT Article 33(3).

Moreover, since dependent claim 12 encompasses the same subject matter as independent claims 13 and 14, for the reasons set forth above with respect to claims 13 and 14 Applicants respectfully submit that, for a second independent reason, claim

12 possesses, with respect to all embodiments of the electrostatic relay disclosed in Kasano, et al. patent, both novelty under PCT Article 33(2) and inventive step under PCT Article 33(3).

For the reasons set forth above, because claims 13 and 14 encompasses using mechanical force, supplied by a cantilever, for forming a fixed, non-switching electrical connection between electrical conductors respectively located on each of two (2) layers of a MEMS structure, Applicants respectfully submit that claims 13 and 14 possess, with respect to all embodiments of the electrostatic relay disclosed in Kasano, et al. patent, both novelty under PCT Article 33(2) and inventive step under PCT Article 33(3).

For these reasons, Applicants respectfully request that the United States International Preliminary Examining Authority issue a Written Opinion for this patent application declaring that claims 1-9 and 11-14 all possess novelty, inventive step and industrial applicability.

Respectfully submitted

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the seesaw 52 reduces voltage which must be applied to actuate the MEMS switch.

FIG. 10 depicts the area of the base wafer 104, illustrated progressively in FIGs. 3, 6 and 7, after the corresponding area of the metalization surface 172 of the glass substrate 174, illustrated in FIG. 9, has been anodically bonded to the front surface 142 of the device layer 122. In bonding the metalization surface 172 to the front surface 142, the metal pattern depicted in FIG. 9 is carefully aligned with the structure micro-machined into the device layer 122 that appears in FIGs. 7 and 8. Bonding of the metalization surface 172 to the front surface 142 in this way establishes the MEMS switch as illustrated in FIGs. 1, 2A and 2B. In the structure depicted in FIGs. 7 and 8, the wires of the electrodes 54a and 54b connecting to the contact pads thereof respectively pass through the serrations in the wall 156 while the switch contacts 56a1, 56a2, 56b1 and 56b2 respectively pass along arms of the U-shaped walls 154 and 156 in close proximity respectively to the ground plates 162a and 162b.

During anodic bonding of the metalization surface 172 to the front surface 142, the cantilevers 166 supporting the grounding islands 152 deflect due to interference between the metal of the ground plates 162a and 162b that is atop each grounding island 152 and of the grounding pads 186 formed on the metalization surface 172 of the glass substrate 174. Mechanical stiffness of the single crystal silicon material forming the cantilevers 166 provides forces which ensure a sound electrical connection between the grounding pads 186 and the portions of the ground plates 162a and 162b juxtaposed therewith at the grounding islands 152.

After the glass substrate 174 has been anodically bonded to the wall 154, the entire outer portions both of the base wafer 104 and of the glass substrate 174 furthest from the device layer 122 are thinned as indicated by dashed lines 192 and 194 in FIG. 10. Preferably, the base wafer 104 and of the glass substrate 174 are thinned in a double side grinding and polishing operation. About half the thickness of each layer is removed with the glass substrate 174 having a final

The Claims

What is claimed is:

1. An integral micro-electro mechanical systems ("MEMS") switch adapted for selectively coupling an electrical signal present on a first input conductor connected to the MEMS switch to a first output conductor also connected to the MEMS switch, the MEMS switch comprising:

a. a monolithic layer of material having micro-machined therein:

i. a seesaw;

ii. a pair of torsion bars that are disposed on opposite sides of and coupled to the seesaw, and which establish an axis about which the seesaw is rotatable; and

iii. a frame to which ends of the torsion bars furthest from the seesaw are coupled, the frame supporting through the torsion bars the seesaw for rotation about the axis established by the torsion bars;

iv. an electrically conductive first shorting bar carried at an end of the seesaw distal from the rotation axis established by the torsion bars;

b. a base that is joined to a first surface of the monolithic layer;

c. a substrate that is bonded to a second surface of the monolithic layer which is distal from the first surface thereof to which the base is joined, the substrate having formed thereon:

i. a first electrode which is juxtaposed with a surface of the seesaw that is located to one side of the rotation axis established by the torsion bars, application of an electrical potential between the first electrode and the seesaw urging the seesaw to rotate in a first direction about the rotation axis established by the torsion bars;

ii. a first pair of switch contacts adapted to be connectable respectively to the first input conductor and to the first output conductor, and which:

(1) are disposed adjacent to but spaced apart from the first shorting bar when no force is applied to the seesaw;

(2) when no force is applied to the seesaw are electrically insulated from each other;

(3) the first shorting bar contacts upon application of a sufficiently strong force to the seesaw which urges the seesaw to rotate in the first direction about the rotation axis established by the torsion bars; and

(4) first electrical conductors that respectively carry electrical signals between the switch contacts and the first input and first output conductors; and

d. a first ground plate which is disposed adjacent to and is electrically insulated from the first electrical conductors;

whereby upon rotation of the seesaw about the rotation axis established by the torsion bars in the first direction to such an extent that the first shorting bar contacts the first pair of switch contacts, the contacting first shorting bar electrically couples together the first pair of switch contacts.

2. The MEMS switch of claim 1 that is further adapted for selectively coupling an electrical signal present on a second input conductor connected to the MEMS switch to a second output conductor also connected to the MEMS switch:

wherein the seesaw carries a second shorting bar at an end of the seesaw that is located on an opposite side of the rotation axis from the first shorting bar; and

wherein the substrate also has formed thereon:

iii. a second pair of switch contacts adapted to be connectable respectively to the second input conductor and to the second output conductor, and which:

(1) are disposed adjacent to but spaced apart from the second shorting bar when no force is applied to the seesaw;

(2) when no force is applied to the seesaw are electrically insulated from each other;

(3) the second shorting bar contacts upon application of a sufficiently strong force to the seesaw which urges the seesaw to rotate in a second direction about the rotation axis established by the torsion bars that is opposite to the first direction; and

(4) second electrical conductors that respectively carry electrical signals between the switch contacts and the second input and second output conductors; and

e. a second ground plate which is disposed adjacent to and is electrically insulated from the second electrical conductors;

whereby upon rotation of the seesaw about the rotation axis established by the torsion bars in the second direction to such an extent that the second shorting bar contacts the second pair of switch contacts, the contacting second shorting bar electrically couples together the second pair of switch contacts.

3. The MEMS switch of claim 2 wherein the substrate also has formed thereon a second electrode which is juxtaposed with a surface of the seesaw that is located to one side of the rotation axis established by the torsion bars which is opposite to the surface of the seesaw with which the first electrode is juxtaposed, application of an electrical potential between the second electrode and the seesaw urging the seesaw to rotate in

the second direction about the rotation axis established by the torsion bars.

4. The MEMS switch of claim 1 that is further adapted for selectively coupling an electrical signal present on a second input conductor connected to the MEMS switch to the first output conductor:

wherein the seesaw carries a second shorting bar at an end of the seesaw that is located on an opposite side of the rotation axis from the first shorting bar; and

wherein the substrate also has formed thereon:

iii. a second pair of switch contacts a first one of which is adapted to be connectable respectively to the second input conductor and a second one of which is connected to that one of the second pair of switch contacts which is adapted to be connectable to the first output conductor, and which:

(1) are disposed adjacent to but spaced apart from the second shorting bar when no force is applied to the seesaw;

(2) when no force is applied to the seesaw are electrically insulated from each other;

(3) the second shorting bar contacts upon application of a sufficiently strong force to the seesaw which urges the seesaw to rotate in a second direction about the rotation axis established by the torsion bars that is opposite to the first direction; and

(4) second electrical conductors that respectively carry electrical signals between the switch contacts and the second input and first output conductors; and

e. a second ground plate which is disposed adjacent to and is electrically insulated from the second electrical conductors;

whereby upon rotation of the seesaw about the rotation axis established by the torsion bars in the second direction to such an extent that the second shorting bar contacts the second pair of switch contacts, the contacting second shorting bar electrically couples together the second pair of switch contacts.

5. The MEMS switch of claim 4 wherein the substrate also has formed thereon a second electrode which is juxtaposed with a surface of the seesaw that is located to one side of the rotation axis established by the torsion bars which is opposite to the surface of the seesaw with which the first electrode is juxtaposed, application of an electrical potential between the second electrode and the seesaw urging the seesaw to rotate in the second direction about the rotation axis established by the torsion bars.

6. The MEMS switch of any one of claims 1 through 5 wherein a fusion bond joins the monolithic layer and the base.

7. The MEMS switch of any one of claims 1 through 6 wherein material forming the monolithic layer is single crystal silicon (Si).

8. The MEMS switch of any one of claims 1 through 7 wherein a sheet of electrically insulating material is interposed between the seesaw and shorting bar(s).

9. The MEMS switch of any one of claims 1 through 8 wherein the base includes a cavity formed therein which abuts the first surface of the monolithic layer, and into which a portion of the seesaw enters upon rotation of the seesaw about the axis established by the torsion bars.

10. (Canceled.)

11. The MEMS switch of any one of claims 1 through 9 wherein the ground plate(s) are disposed on the monolithic layer.

12. The MEMS switch of claim 11 wherein the monolithic layer includes a cantilever which supports at a free end thereof a grounding island which at an end thereof which is distal from the cantilever carries a portion of the ground plate, the portion of the ground plate at the end of the grounding island being urged by force supplied by the cantilever into intimate contact with an electrical conductor that is disposed on the substrate.

13. A micro-electro mechanical systems ("MEMS") electrical contact structure adapted for forming an electrical contact between an electrical conductor that is disposed on a first layer of a MEMS device and an electrical conductor that is disposed on a second layer of the MEMS device, the MEMS electrical contact structure comprising:

a cantilever included in the second layer; and

an electrical contact island also included in the second layer which is supported at a free end of the cantilever, the electrical contact island at an end thereof which is distal from the cantilever carrying a portion of the electrical conductor that is disposed on the second layer, the portion of the electrical conductor at the end of the electrical contact island being urged by force supplied by the cantilever into intimate contact with the electrical conductor that is disposed on the first layer.

14. A micro-electro mechanical systems ("MEMS") structure comprising:

a first layer having disposed thereon an electrical conductor; and

a second layer also having disposed thereon an electrical conductor, the second layer including:

a. a cantilever; and

b. an electrical contact island which is supported at a free end of the cantilever, the electrical contact island at an end thereof which is distal from the cantilever carrying a portion of the electrical conductor that is disposed on the second layer, the portion of the electrical conductor at the end of the electrical contact island being urged by force supplied by the cantilever into intimate contact with the electrical conductor that is disposed on the first layer.

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FIG. 7

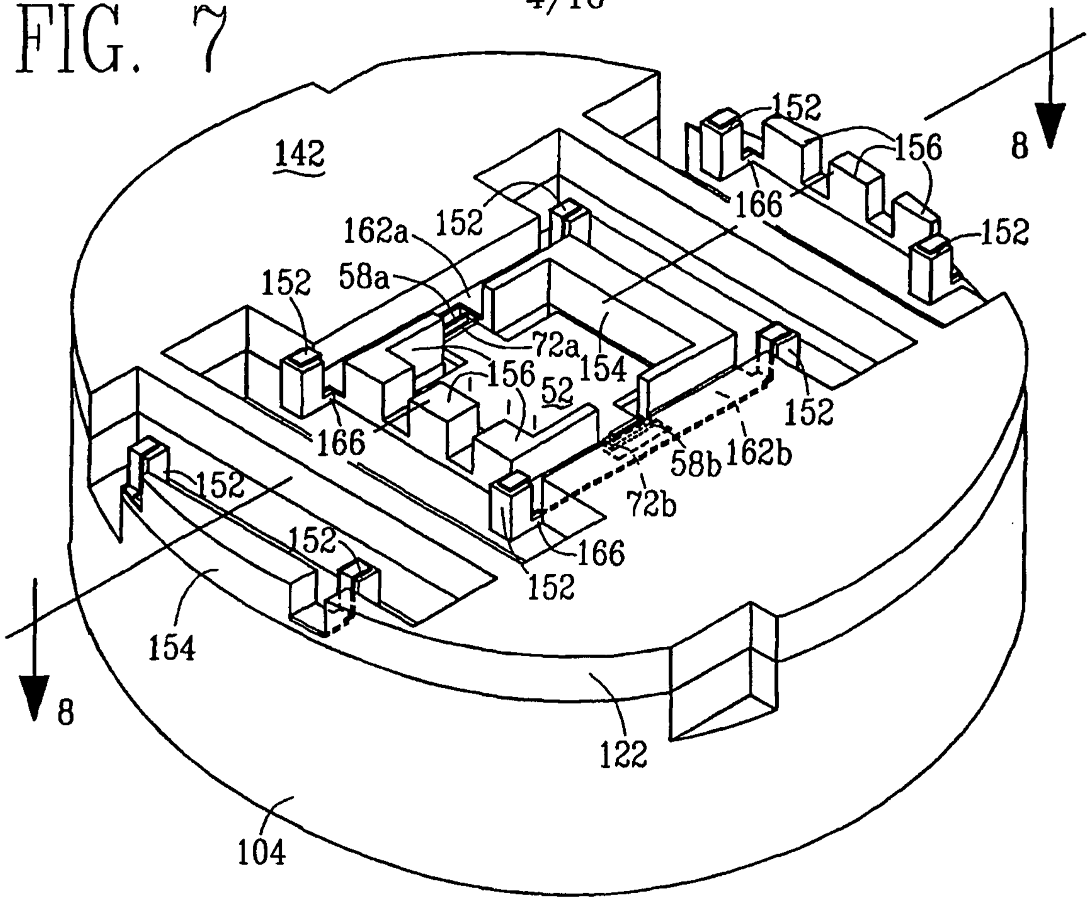

FIG. 9

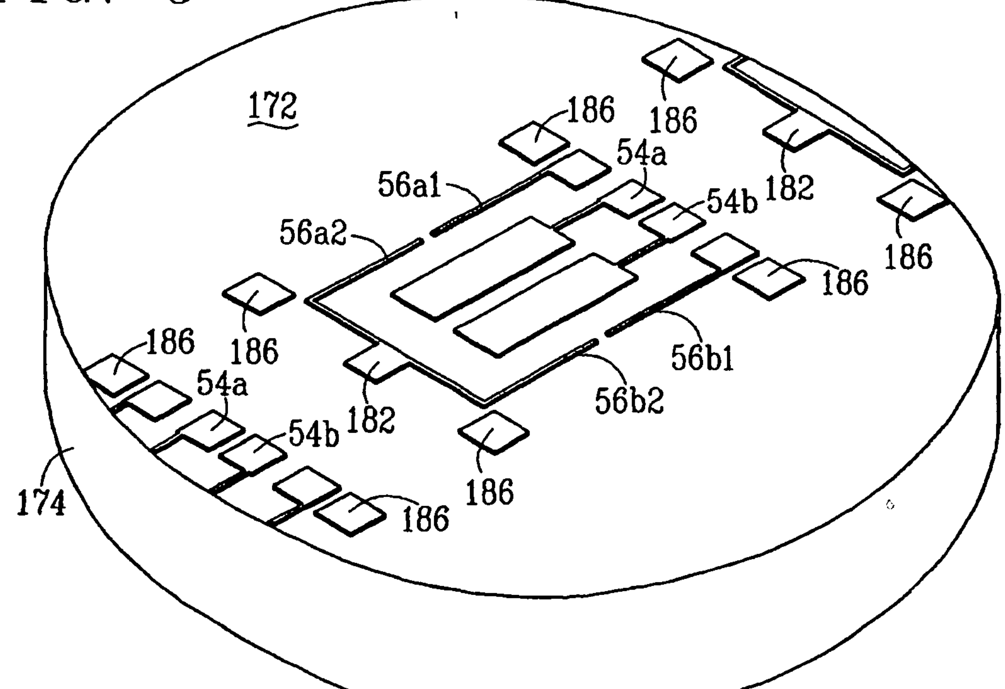

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FIG. 8

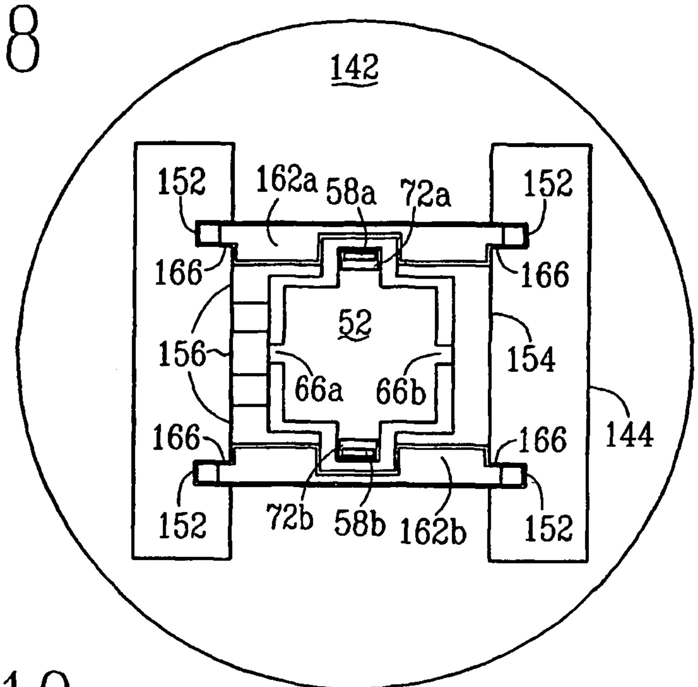

FIG. 10

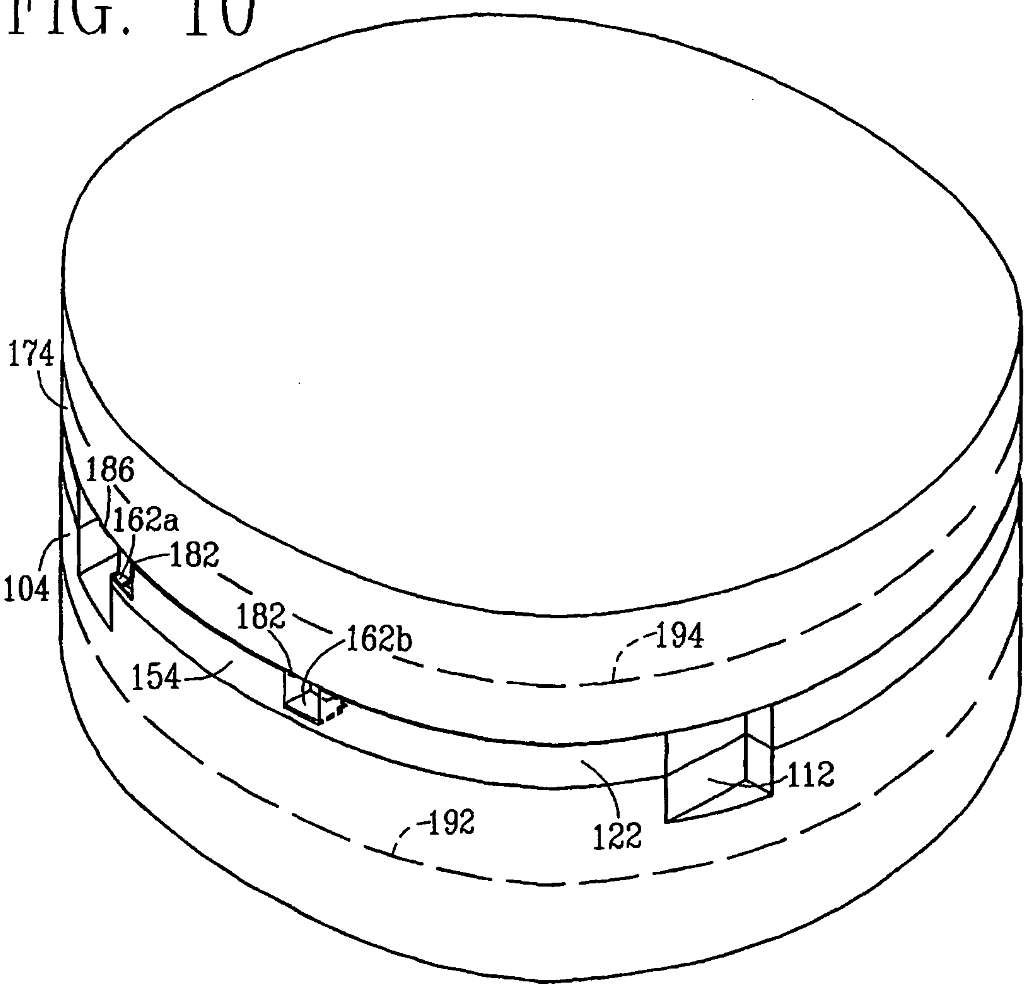

FIG. 11

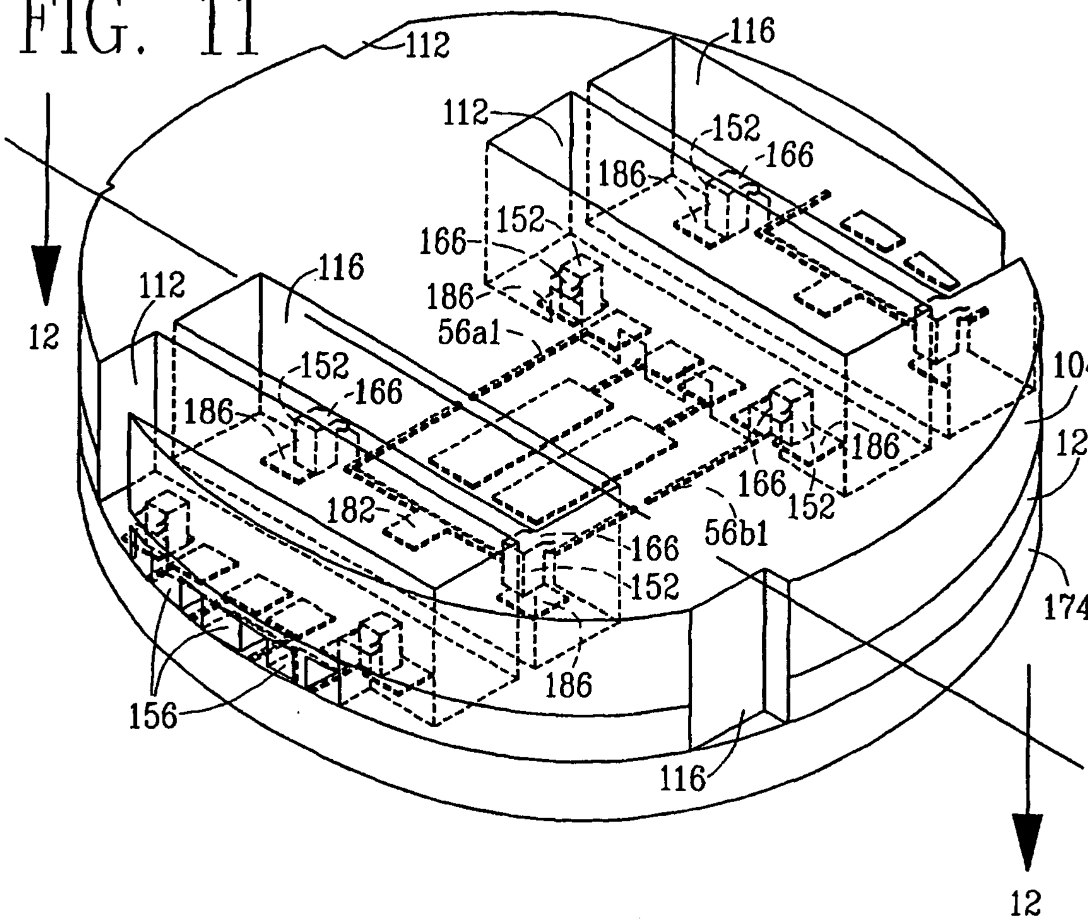
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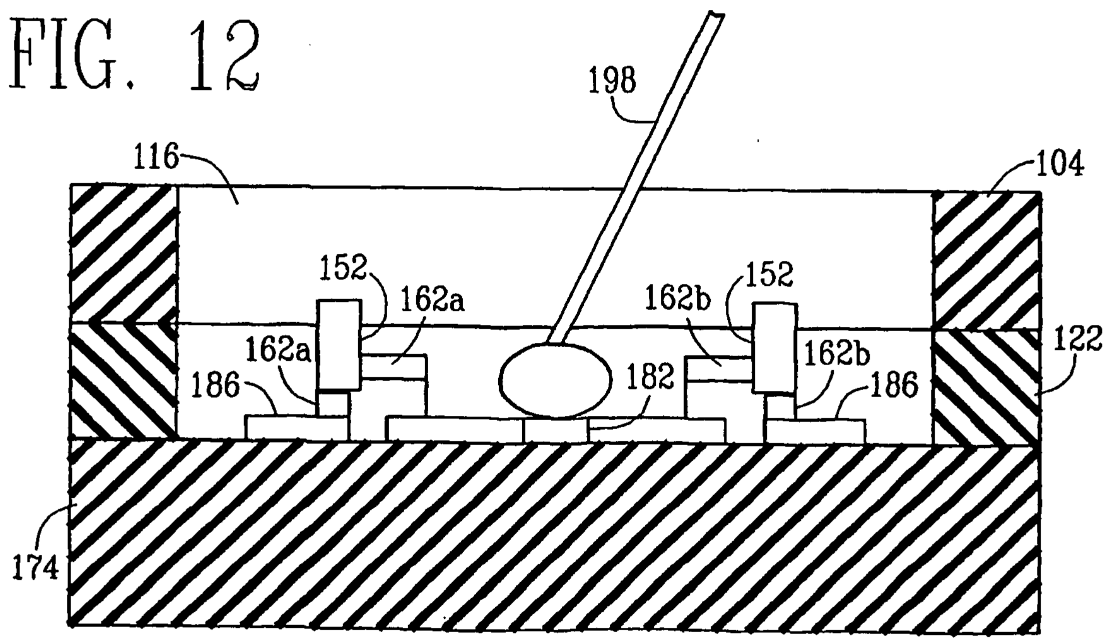
FIG. 12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174